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Research Report 1569

Bradley Fighting Vehicle Gunnery: The Use of the Protective Mask in the Conduct of Fire Trainer

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Margaret S. Salter
U.S. Army Research Institute

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July 1990

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An experiment was designed to reassess requirements for Bradley Fighting Vehicle (BFV) institutional gunnery training. The question of the need to wear the nuclear, biological, chemical (NBC) protective mask while training in the Conduct of Fire Trainer (COFT) gunnery simulator was addressed by an experiment in which experienced Bradley gunners and commanders fired a preselected set of COFT exercises both with and without the mask. Results indicated that on several critical gunnery performance variables, crew performance was significantly slower in the masked condition. The results, while preliminary, indicate that crews must fire wearing the mask whenever possible, in order to overcome possible performance degradation produced by the mask.

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Research Report 1569

Bradley Fighting Vehicle Gunnery: The Use of the Protective Mask in the Conduct of Fire Trainer

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FOREWORD

This report is one of several focusing on Bradley Fighting Vehicle training, and in particular, gunnery training within the Bradley's primary gunnery simulator, the Conduct of Fire Trainer (COFT). The research was undertaken by the Army Research Institute (ARI) Fort Benning Field Unit under Research Task 3.3.2, Developing Training for Individual and Crew-Served Weapons. This project is part of the overall task to assess instructional strategies and technologies to improve weapon system training and is also an outgrowth of work initiated under a previous task, Advanced Methods and Systems for Fighting Vehicle Training. Sponsorship for Bradley research was initially provided under a 1983 Memorandum of Understanding between the Training Technology Agency at TRADOC, the U.S. Army Infantry School, and ARI.

The initiative for this research was provided by concerns expressed by the Bradley Instructor Detachment of the 29th Infantry Regiment at Fort Benning. Training for combat in a nuclear, biological, and chemical (NBC) environment was rarely practiced in the institutional setting, due to time limitations in the Bradley programs of instruction and to the difficulty of obtaining the appropriate NBC protective masks for students. Although all soldiers receive the standard M17 NBC protective field mask, the M25 tanker's mask, mandatory for a vehicle crewman, was unavailable for use in institutional Bradley training. This research project was therefore designed to assess the impact on gunnery performance of wearing the M25 mask. If wearing the mask produced no significant effects on gunnery performance, the lack of the appropriate mask (and hence the training) would not be critical. However, a negative effect on performance would bolster the argument for providing masks for students.

The results of this project have been briefed to personnel throughout the 29th Infantry Regiment, its Bradley Proponency Office, the Bradley Instructor Detachment, and to the Conduct of Fire Trainer Branch. The interest generated by the project has resulted in the permanent availability of the appropriate protective mask for Bradley gunnery students, together with changes to the programs of instruction requiring its use.

EDGAR M. JOHNSON
Technical Director

BRADLEY FIGHTING VEHICLE GUNNERY: THE USE OF THE PROTECTIVE MASK IN THE CONDUCT OF FIRE TRAINER

EXECUTIVE SUMMARY

Requirement:

This research was undertaken to determine the effects of simulated nuclear, biological, and chemical (NBC) conditions on gunnery performance in the Bradley Fighting Vehicle Conduct of Fire Trainer (COFT) simulator. It was based on the need to assess current institutional requirements for NBC training.

Procedure:

Experienced Bradley crews were required to complete two sets of each of three COFT gunnery exercises, one set while wearing the M25 NBC protective mask and another set without the mask. Their gunnery performance was compared for the two conditions.

Findings:

On each of three sets of exercises and on each of four main gunnery variables, crews showed significantly slower performance when firing masked than when firing unmasked. Masking had slightly more impact on time to identify the target and to fire the first round than on time to achieve the first hit and time to kill the target. However, all measures clearly showed degradation in the masked condition. These results, although preliminary, indicate that masking has a negative effect on Bradley gunnery performance, at least as measured in the primary gunnery simulator, the COFT. The number of rounds fired for each exercise was not significantly affected by wearing the mask.

Utilization of Findings:

If personnel are to train as they intend to fight, this training must plan for the possibility of NBC warfare. For the COFT to fulfill its role as a combat gunnery trainer, training within the COFT must include NBC (masked) gunnery so Bradley crews can acquire and maintain these skills. Since the protective mask has negative impact on performance, both units and institutional training programs must make NBC gunnery training mandatory. Bradley crews must fire masked whenever possible, in order to overcome the performance degradation produced by the mask.

BRADLEY FIGHTING VEHICLE GUNNERY: THE USE OF THE PROTECTIVE MASK IN THE CONDUCT OF FIRE TRAINER

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Introduction

Field Manual (FM) 25-100, Training the Force, begins with the reminder that training prepares soldiers, leaders, and units to fight and win in combat: "We train the way we intend to fight because our historical experiences amply show the correlation between realistic training and success on the battlefield" (FM 25-100, Department of the Army, 1988, p. 1-1). Using the concept of battle-focused training, peacetime training requirements are derived from wartime missions and task lists. To achieve the realism required to obtain combat level standards, training must include, wherever possible, inclement weather conditions, planned loss of key personnel, battlefield debris, and simulated NBC (nuclear, biological, chemical) conditions. U.S. Army doctrine is clear regarding the need for realistic NBC training. It must be integrated throughout each of the seven Battlefield Operating Systems: maneuver, fire support, air defense, command and control, intelligence, mobility and survivability, and combat service support. Furthermore, realistic training uses training devices and simulators to replicate the stress, sounds, and conditions of combat.

Battle-focused training applies to both unit and institutional training environments. The research described here used an institutional gunnery training device. The specific purpose of the research was to determine the effects of simulated NBC conditions on gunnery performance in the primary Bradley Fighting Vehicle (BFV) gunnery simulator, the Conduct of Fire Trainer (COFT).

Need for NBC Training

In an article in Defense 89, T. J. Welch called for vigilance in the NBC arena:

> The United States must be fully prepared to neutralize any perception by our adversaries that they could gain an advantage over us by initiating chemical or biological warfare. Should that deterrence fail, we must have the capability to survive the attacks [and] continue operating effectively (Welch, 1989, p. 19).

To be prepared to fight in an environment characterized by nuclear and chemical weapons, forces must be organized, equipped, and trained to meet the challenge. Field Manual 1-102, Army Aviation in an NBC Environment (Department of the Army, 1985a), states that for the Army to be able to conduct and sustain

operations on NBC battlefields, commanders and soldiers must be prepared physically and mentally to win on the NBC battlefield. It continues: "Training is the most important factor in achieving NBC readiness. Commanders must insure they integrate realistic and demanding NBC training throughout combined arms operations" (FM 1-102, Department of the Army, 1985a, p. 32). Similarly, Field Manual 7-7J, The Mechanized Infantry Platoon and Squad (Bradley) (Department of the Army, 1986b), stresses that ability to fight in a nuclear environment depends on how well individual and collective tasks have been learned in training. "When the platoon can do all the individual and collective tasks while employing nuclear protective measures, its chances of continuing to be combat effective on the battlefield are improved" (FM 7-7J, Department of the Army, 1986b, p. M-4).

NBC Protection

An overview of NBC protection is found in the Chemical School's Field Manual 3-100, NBC Operations (Department of the Army, 1985c). Three other manuals cover specific areas. Field Manual 3-3, NBC Contamination Avoidance (Department of the Army, 1986a), covers defensive measures and use of NBC reporting and warning systems. Decontamination is covered in Field Manual 3-5, NBC Contamination (Department of the Army, 1985b) and includes tactical decisions to be made by commanders. Hasty and battlefield decontamination techniques are also covered.

Field Manual 3-4, NBC Protection (Department of the Army, 1985d), describes NBC protective clothing and equipment, defensive preparations, individual actions during and after an attack, and collective protection. Gloves (an outer black impermeable butyl rubber glove for protection and an inner thin white cotton glove for perspiration absorption) protect against chemical agents and vapors. Rubber footwear covers worn over combat boots protect feet from contamination. The green butyl-coated nylon cloth helmet cover protects the helmet from chemical and biological contamination.

Protective masks keep wearers from breathing air that is contaminated with chemical and/or biological agents. The M17A2 standard field mask (issued to every soldier) has a voicemitter to facilitate communication, a drinking tube, and two outserts to protect eye lenses and prevent fogging. The single eyepiece M25/M25A1 tank protective mask (for crew members of armored vehicles and aircraft) also protects against chemical and biological agents. In an armored vehicle, the mask connects to a filter unit such as the M13A1 gas particulate filter unit (GPFU) which forces temperature controlled air to the facepiece. A microphone assembly in the mask permits communication within and between vehicles through the vehicle communications system.

Mission-Oriented Protective Posture (MOPP)

Survival and performance in an NBC environment depend on the proper use of protective equipment and techniques. The term mission-oriented protective posture (MOPP) has been adopted to describe individual protective clothing and equipment which is referred to as MOPP gear. MOPP gear includes all of the things necessary for soldier protection: chemical suit/overgarment with footwear covers (overboots), glove set (rubber gloves with liners), mask (field, tank, or aviation versions), helmet cover, mask hood, chemical first aid antidotes, skin decontamination kit, and detector paper. MOPP is a flexible use of protective clothing and equipment that balances protection with possible performance degradation. MOPP levels are defined by the amount of protective equipment being worn and can be raised or lowered through five operational levels from MOPP ZERO to MOPP4. Table 1 shows the protection offered by each increasing level of MOPP.

Table 1

Levels of Mission Oriented Protective Posture

	MOPP0	MOPP1	MOPP2	MOPP3	MOPP4
OVERGARMENT	near by	worn*	worn*	worn*	worn
OVERBOOTS	near by	carried	worn	worn	worn
MASK/HOOD	carried	carried	carried	worn*	worn
GLOVES	near by	carried	carried	carried	worn

Note. * In hot weather the coat or hood can be left open for ventilation. (Table adapted from Field Manual 3-100, Department of the Army, 1985, p. 3-5.)

Some systems offer collective protection instead of requiring individual soldiers to maintain high levels of MOPP. This reduces the degradation caused by wearing MOPP gear by reducing the heat and stress effects of MOPP or eliminating the need to wear it. Collective protection equipment may be any of four systems. A ventilated facepiece supplies filtered air through hoses to ventilate the individual mask. An overpressure system pressurizes an enclosure with air that has been filtered to remove NBC contamination. Air is purified by forcing it through particulate and gas filters. Hybrid protection is a combination of overpressure and the ventilated facepiece systems. Total protection provides a hybrid system with air conditioning. Army manuals state that collective protection in tanks increases effectiveness for crews which can operate in lower levels of MOPP. Hybrid systems such as in the M1 tank can prevent vapor

contamination of the vehicle interior and increase the amount of time a crew can remain unmasked. The M60 tank uses a ventilated facepiece where forced air reduces breathing resistance caused by the mask (FM 3-100, Department of the Army, 1985c).

Performance Degradation

Despite the advantages and protection provided by wearing MOPP gear, there are numerous disadvantages, particularly in reduced efficiency. The longer a soldier is in MOPP4, the lower his efficiency. Rubber gloves make using tools and weapons awkward and they are easily ripped. The overgarment reduces airflow and adds bulkiness; the overboots may slow procedures because personnel are more deliberate in placing their feet. Extended operations in MOPP gear are fatiguing and discouraging (FM 3-5, Department of the Army, 1985b). Although "troops should be physically and psychologically conditioned by frequent training in protective clothing" (FM 25-100, Department of the Army, 1988, p. 4-4), "soldiers who are required to perform duties involving the senses or related functions, such as manning an observation post, tend to operate at lower levels of efficiency while wearing protective equipment" (FM 7-7J, Department of the Army, 1986a, p. M-20).

Some skill degradation is unavoidable while wearing MOPP gear. Five major areas are: (1) fine motor skills - wearing protective gloves reduces ability to grasp tools and manipulate controls; (2) gross motor skills - MOPP gear slows overland movement; (3) visual skills - wearing a mask reduces acuity; (4) hearing skills - wearing the hood reduces hearing level; (5) stamina - wearing MOPP gear causes heat and mental stress (FM 3-100, Department of the Army, 1985c, p. 3-3).

MOPP gear has a physiological and psychological impact on personnel. Physiological effects may include heat illness, water loss, vision or respiration problems, and fatigue. Psychological effects may include claustrophobia, impaired perception, and panic symptoms. Physical limitations include reduced manual dexterity, loss of senses, and restriction of body movement. Maintenance problems come from bulky gloves and vision impaired or distorted by masks (FM 1-102, Department of the Army, 1985a). To function effectively in the NBC environment, personnel must be physically and mentally acclimatized to wearing protective equipment, particularly if tasks require attention and dexterity.

Combat power drops in MOPP4. Because soldiers cannot see as clearly when in MOPP, observation and target acquisition are reduced. Fire support is less responsive because communication is more difficult and time consuming. Mobility is reduced because soldiers slow down to control heat build-up in their MOPP gear. Leadership is more difficult because everyone looks alike in MOPP4 and soldiers may feel isolated (FM 3-100, Department of

the Army, 1985c). Individual mission performance depends on training and proficiency. Welch (1989, p. 21) says "Soldier performance and Air Force sortie generation rates drop at least 50 percent in a relatively short period (two to four hours) and continue to deteriorate as time passes." Wagner and Gold (1982, cited in Abel, 1987) state that the decrement in operational effectiveness, dependent on task complexity, MOPP level and the weather, has been estimated as high as 50% of the effectiveness without the equipment. The protective mask interferes with communication and reduces the field of view, making optical sights and night vision devices difficult to use. For an aviator, the M24 mask reduces peripheral vision by limiting the range of motion for the head to 140 degrees, requiring the head to be turned to look beyond the edge of the mask. The mask may also distort vision in the cockpit, especially during night operations (FM 1-102, Department of the Army, 1985a).

Training to Overcome Effects of Wearing MOPP Gear

However, as noted in Field Manual 1-102, realistic training permits personnel to adapt to wearing protective gear and for most individuals, six or seven days of strenuous activity in MOPP4 will condition the body to heat stress. They acclimate to the protective clothing and learn their personal limitations. To realize their limits, soldiers must conduct the same activities they normally do in an uncontaminated environment (FM 1-102, Department of the Army, 1985a). "Soldiers fighting in protective clothing and masks tire quickly. Heat exhaustion casualties increase, more time is required to get the job done" (FM 3-87, Department of the Army, 1980, p. 1-6). Soldiers in protective gear fire less proficiently, move more slowly, and must rest more often. The degradation caused by heat buildup, fatigue, and stress affects soldiers who do not usually wear protective gear more seriously than soldiers who do. Physical training in a mask is effective in strengthening individual endurance, but unit readiness comes from practicing battle drills, doing maintenance, eating, sleeping, communicating, and firing weapons in MOPP gear (FM 3-100, Department of the Army, 1985c).

The amount of degradation can be reduced by acclimation and training and the better-trained the individual soldier, the less impact MOPP has on his performance. Psychological symptoms may be reduced by continually reinforcing NBC training and by education on NBC survival measures. During peacetime soldiers should receive extensive training in full MOPP gear to become more confident in the equipment and to increase the time that it can be worn safely (FM 3-4, Department of the Army, 1985d).

Research on Effects of MOPP Gear on Performance

A limited amount of research has been done on the effects of wearing MOPP. An early study by Montague, Baldwin and McClure

(1959) measured effects of masking immediately after donning the mask, and again five hours later. This research studied the impact of the E13R9 mask, predecessor to the M17, on individual soldier performance in seven areas: driving vigilance, radio communication, optically aided and un-optically aided detection of human targets, firing the M1 caliber .30 rifle, running cross country, and unaided voice communication. All tasks showed performance decrement at both time periods, with greatest decrement in voice communications. Although this study was done more than 30 years ago, the conclusions remain valid:

> Current Army training provides periodic practice for troops in wearing the mask. In view of the tendency for skilled performance to deteriorate under the disorganizing impact of combat, however, such mask-wearing practice might well be modified so as to insure that each officer and enlisted man becomes fully experienced in performing, while masked, all the duties and activities that he would have to perform in combat in his particular job or MOS. All personnel ought to receive periodic practice in performing their own particular duties while actually wearing the mask for prolonged periods of time (Montague et al., 1959, p. 16).

The current M17 and M25 protective masks are quite different from each other, reflecting the designated user's needs. Garinther and Hodge (1988) began a series of studies on speech intelligibility after noting the detrimental effects caused by trying to speak while wearing the M25 mask. The M17 mask, intended primarily for ground soldiers, has a special voicemitter which enables personnel to communicate with one another at distances up to 20-30 meters. The M25 mask incorporates an internal microphone for connection to an intercom or radio communication system on the other hand and is intended for interior use by combat vehicle crewmen. Its effective communication range outside of a vehicle proved to be considerably less than 10 meters.

Abel (1987) noted that performance degradation in MOPP gear has been examined, but little information is available on the performance of armor crewmen under NBC conditions. This is surprising since tank gunnery requires visual acuity, manual dexterity, and verbal communication for successful task performance. Existing research has focused on the physiological aspects of heat stress and fatigue rather than performance variables such as the psychomotor tasks required in tank gunnery.

In an experiment testing the effects of NBC protective equipment on normal and degraded gunnery on experienced gunners firing the M1 tank COFT, Abel (1987) found that MOPP gear (mask and gloves only) degraded aiming error performance under normal operating conditions. When the tank gunnery system was further degraded by one or more systems being non-operational, NBC gear

affected fire time, percent hits, and aiming error (distance in mils from the reticle to the center of target mass at time of round impact), particularly in long range target engagements. A second experiment, however, showed the impact to be more due to emergency operational conditions (overall degradation) than to wearing MOPP. Abel cautioned that this sample of gunners had extensive experience and their successful performance in MOPP gear may have been reflective of prior training.

Limitations as a result of wearing the protective mask have been reported. Muza notes that degraded vision is a function of several factors, including restrictions in the field of view, reduced acuity, and altered space and distance perception. He suggests that decrements depend upon the specific task and conditions as tasks requiring a large visual field are degraded by mask wear whereas tasks utilizing a small visual field might not be affected (Muza, 1986, cited in Abel, 1987).

The impact of the protective mask on visual acuity was examined by testing subjects on tracking a target at a constant rate across a visual field while the direction of the target varied randomly (Wiley, Behar, Chiow, & Holly, 1977, cited in Abel, 1987). The mask interfered with the ability to detect and track a rapidly moving target. For those wearing a mask, the target angular size had to be increased up to 38% over the no-mask condition to achieve a 95% detection rate. These results were extended by Kobrick and Sleeper when they measured response times to visual stimuli. The response times for detecting visual signals were significantly longer for those subjects wearing the mask in MOPP4 (Kobrick & Sleeper, 1986, cited in Abel, 1987).

The Conduct of Fire Trainer (COFT)

The simulator used in the NBC experiment reported here was the Bradley COFT, a computer driven high fidelity gunnery trainer which functionally replicates the BFV's turret interior. It presents computer generated targets in combat scenarios and enables a commander and gunner to practice the skills necessary to hit and kill single and multiple tank, personnel carrier, troop and helicopter targets at varying ranges and under varying visibility conditions and equipment readiness. COFT training requires that a commander and gunner correctly perform the elements of target engagement to progress through a programmed training matrix. An instructor/operator (IO) monitors the crew's techniques and critiques them at the end of a training session. A computer printout details performance within each exercise by recording such measures as number of targets hit, number of rounds fired, and target identification time. (For further information on the COFT, see General Electric Company, 1984.)

Rationale

As a part of its training mission, the Bradley Instructor Detachment (BID) teaches gunnery on ranges and in the COFT gunnery simulator. Portions of this program focus on training for gunnery under NBC conditions when the soldier must wear MOPP gear. Typically, however, little is done to insure that Bradley students practice gunnery in MOPP. The mask, although frequently used on the live fire range, is rarely used in COFT training, despite the fact that there are certain exercises specifically intended to be shot as NBC exercises. Part of the problem has been the unavailability of the appropriate protective masks.

Units are issued the M25A1 protective "tanker's" mask which has one clear eyepiece and a combat vehicle crewman (CVC) microphone hookup to enable crews to maintain communication. However, for the COFT, authorization (and therefore availability) has been limited to the M17A1 mask. The M17A1 is unsuitable for Bradley COFT use for several reasons. Its two-sectioned eyepiece prevents the gunner from getting close to the single eyepiece of the integrated sight unit (ISU). More significantly, the M17A1 does not have a microphone hookup to the CVC helmet. Therefore a masked commander and gunner cannot hear each other clearly, and crew coordination, essential to Bradley gunnery, deteriorates. Additionally, in the COFT, where training depends on input from the IO located outside the turret, poor communication through the M17A1 mask means that the IO cannot hear the crew. This presents an additional and severe training problem. Therefore, BID needs the M25A1 mask, rather than the unsuitable M17A1 mask. The present alternative, no COFT NBC training, is unacceptable.

The experiment was designed, therefore, to determine the impact on gunnery performance of wearing the NBC protective mask by a comparison of performance with and without the M25A1 mask. If there is significant impact, the conclusion can be drawn that it is important for personnel training in the institution to fire using the M25A1 mask for NBC training to prepare themselves for unit gunnery. If the mask has no impact on gunnery performance, then the lack of the appropriate mask during institutional training is less important.

Method

Design

Each crew entered the COFT and fired a preselected warm-up exercise. Three masked and three unmasked exercises, counter-balanced for masking, were fired, using different replications or iterations of the same three exercises for the two conditions. The elapsed time per crew was approximately one and one half hours. Gunnery performance, as measured by computer generated

variables, was compared for the two conditions and the three exercises. NBC conditions were simulated by the wearing of the M25A1 protective mask.

Subjects

Data were collected from 33 crews from the BID. Missing data from several crews reduced the total to 27. Skill levels, rank, duty position, and prior experience were irrelevant since each crew was compared with itself. Experienced crews were selected for several reasons. Other battle rostered crews were available in the battalion, but their gunnery abilities were unknown and probably more variable than those within BID. Similarly, although there are many BFV students, as novices their gunnery ability is limited. Additionally, institutional training time is too short to deviate from the POI for experimentation. Finally, if wearing the mask impacts on gunnery performance for experienced BID gunners, it will certainly make a difference for inexperienced gunners.

Exercises

The COFT exercises, suitable in degree of difficulty for sustainment crews, contained both long and short range multiple targets, with daytime limited visibility conditions and simulated effects of friendly and enemy fire. Target models included tanks, personnel carriers, and helicopters. No malfunctions requiring manual mode or auxiliary sight use were included. (See Appendix A for the specific exercises and target information.) Exercise 1 contained short range targets (1190 to 1430 meters) and Exercises 2 and 3 contained targets at longer ranges (1750 to 2050 meters and 1680 to 2040 meters respectively). Different iterations of the same exercise consist of identical target presentations occurring in a different order. The alternate iterations are considered equivalent.

Based on the COFT's progressive training matrix, Exercise 2 may be considered slightly more difficult than Exercise 3 since it is an exercise used for testing within the COFT structure and cannot be omitted. However it is equally possible to argue that since Exercise 3 follows 2 in the normal progression and cannot be undertaken without successful prior performance on Exercise 2, it is therefore more difficult. As used in this experiment, however, they are nearly identical, and both are more difficult than Exercise 1. For experienced crews, the impact of degrees of difficulty is relatively minor; all crews have the skills required to perform successfully on any of the exercises.

Performance Measures

The following performance measures from the COFT computer-generated Performance Analysis were assessed: target

identification time (ID), time to fire the first round (FIRE), time to achieve the first hit on target (HIT), time to kill the target (KILL), and the total number of rounds fired (RDS) in the exercise. Unlike the variable RDS, which is an independent measure, the variables ID, FIRE, HIT, and KILL, measured in seconds, are not independent of each other. The times (as defined by tha structure of the COFT system) are sequentially cumulative and are therefore mathematically correlated. Table 2 shows the actual intercorrelations between these measures for the 27 crews in the unmasked (normal) condition for each of the three exercises. Despite their obvious relationship, these variables are useful for assessing the relative time it takes to achieve each of the major steps in the gunnery sequence. (Only the unmasked condition correlations are shown since unmasked is the primary or base condition.)

Table 2

Correlations between Performance Variables (Unmasked Condition) for COFT Exercises

	EXERCISE 1			EXERCISE 2			EXERCISE 3		
	FIRE	HIT	KILL	FIRE	HIT	KILL	FIRE	HIT	KILL
ID	.51**	.07	.31	.78**	.76**	.77**	.61**	.65**	.58**
FIRE		.54**	.49*		.90**	.88**		.93**	.86**
HIT			.95**			.88**			.88**

Note. * indicates $p<.05$; ** indicates $p<.01$.

Due to the nature of the scoring procedures, the experimental aspects of the gunnery, and the artificiality of donning and/or removing the NBC mask, the absolute times reported here are not necessarily indicative of potential gunnery performance; only the difference in times between masked and unmasked conditions is important. The key gunnery performance variables are the four providing information on the time that elapsed before a crew's targets were killed. As will be discussed later, round count is less accurate.

Results

The performance data was analyzed using the general linear model analysis of variance (ANOVA) (Cody & Smith, 1987; SAS Institute Inc., 1985) (see Appendix B). Table 3 shows the means and standards deviations over all exercises on each of the five variables for both masked (W) and unmasked (WO) conditions and Table 4 shows the overall means by condition and exercise.

Table 3

Summary Means and Standard Deviations (N = 27)

		EX 1 WO	EX 1 W	EX 2 WO	EX 2 W	EX 3 WO	EX 3 W
ID	M	3.80	4.86	6.24	7.54	4.71	6.09
	SD	1.96	2.39	2.77	3.02	2.02	2.63
FIRE	M	16.68	18.04	22.14	23.49	21.64	23.66
	SD	2.81	3.08	3.45	3.77	4.19	3.63
HIT	M	19.95	21.23	26.01	27.64	25.42	26.89
	SD	3.20	3.28	3.72	3.87	3.58	3.24
KILL	M	22.64	23.41	28.68	30.37	28.74	29.84
	SD	3.40	3.34	3.68	3.27	3.65	3.53
ROUNDS	M	61.74	59.93	85.41	83.15	87.30	77.85
	SD	14.73	17.48	23.70	19.75	25.15	18.77

The analyses indicate significant main effects for both the mask and the exercise on all but one variable; no significant interactions occurred. The near totality of the effects is not surprising in view of the significant correlations between variables as shown in Table 2. (Further statistical information is presented in Appendix B.) For identification (ID) times, the effects of both exercise ($F(2,52) = 25.52$, $p<.0001$)) and mask ($F(1,26) = 10.40$, $p=.0034$)) were very strong. Similarly strong effects occurred for exercise ($F(2,52) = 85.39$, $p<.0001$) and mask ($F(1,26) = 8.81$, $p=.0063$) for the time to fire the first round (FIRE) at the target.

Table 4

Overall Means and Standard Deviations by Condition and Exercise

		MASK	NOMASK	EX 1	EX 2	EX 3
ID	M	6.16	4.92	4.33	6.89	5.40
	SD	2.31	1.78	1.95	2.31	2.02
FIRE	M	21.73	20.16	17.36	22.82	22.65
	SD	2.93	3.05	2.50	3.09	3.39
HIT	M	25.26	23.80	20.59	26.83	26.16
	SD	2.87	3.10	2.80	3.12	2.89
KILL	M	27.87	26.69	23.03	29.53	29.29
	SD	2.71	3.11	2.93	2.94	3.08
ROUNDS	M	73.64	78.15	60.83	84.28	82.57
	SD	14.36	16.56	12.81	19.68	18.15

In both cases, masking increased the time required to identify the target, and to start the engagement sequence by firing the first round. Exercise 1 was the easiest, reflected in its consistently shorter times to identify and fire. This ordering effect is consistent with the internal structure of the COFT progressive training system.

Significant effects occurred on time to achieve the first hit on target (HIT) for exercise ($F(2,52) = 125.40$, $p<.0001$) and mask ($F(1,26) = 7.34$, $p=.0118$)) and for time to kill the target (KILL) for exercise ($F(2,52) = 130.83$, $p<.0001$) and mask ($F(1,26) = 6.41$, $p=.0178$). Again, masking increased the time required to hit and then kill the targets, and Exercise 1 continued to be easiest.

The final comparison, the number of rounds fired (ROUNDS), was significant for exercise ($F(2,52) = 34.44$, $p<.0001$) but not for the effects of the mask ($F(1,26) = 3.82$, $p=.0616$). Exercise 1 overall required fewest rounds tc complete. As before, Exercise 1 was clearly diferent from the other two. This finding is not unexpected; the reason for the direction of the difference remains open to discussion. The finding of no significant difference between the masked and unmasked condition in number of rounds fired also has several possible interpretations as does the direction of the difference. Table 5 provides an overview of the analyses.

Table 5

ANOVA for Effects of Masking over Three Exercises

Variable	Source	DF	F	p
ID	EXERCISE	2	25.52	0.0001
	MASK	1	10.40	0.0034
	EXERCISE*MASK	2	0.16	0.8566
FIRE	EXERCISE	2	85.39	0.0001
	MASK	1	8.81	0.0063
	EXERCISE*MASK	2	0.48	0.6188
HIT	EXERCISE	2	125.40	0.0001
	MASK	1	7.34	0.0118
	EXERCISE*MASK	2	0.08	0.9216
KILL	EXERCISE	2	130.83	0.0001
	MASK	1	6.41	0.0178
	EXERCISE*MASK	2	0.57	0.5700
ROUNDS	EXERCISE	2	34.44	0.0001
	MASK	1	3.82	0.0616
	EXERCISE*MASK	2	1.03	0.3651

Discussion

Gunnery Performance Variables

The results of the analyses very clearly indicate the negative impact of the mask on the four gunnery performance variables, times to ID, FIRE, HIT and KILL. In every case, the elapsed time was longer (therefore slower) for crews while they were wearing the protective mask than when they were not. The initial portions of the target engagement sequence appear to be more severely affected by wearing the mask than the final parts.

This may be explained by the fact that identification requires the crew to search for, acquire, and identify a target, a task made more difficult than normal by the limited (and possibly distorted) field of view imposed by the protective mask. Similarly, the initial time to fire the first round may be longer in the mask condition because of the necessity to arm the system and select the appropriate switches (range, ammunition, rate of

fire, etc.) before firing. Both of these tasks may be made more difficult due to the mask's impact on communications.

By the time the crew has identified and fired on the target, the detrimental effect of the mask may have been reduced since hitting and killing the target (once it has been located accurately) are less susceptible to the mask per se, than to potential gunner error. The final portions of the firing process, adjusting initial fire and making corrections to kill the target, may be less severely impacted upon because the gunner is, looking through the ISU in high magnification, already using a very small field of view and corrections after the initial rounds are relatively small.

That there is a significant difference between the exercises on each of the four gunnery performance variables is not surprising, given the internal structure of the COFT training system and the sequencing of exercises within its program of instruction. Since Exercise 1 contained targets presented at relatively shorter range than the targets in Exercises 2 and 3, Exercise 1 would be expected to be easier, as measured by shorter times. This was confirmed. Similarly, Exercises 2 and 3 are, by their descriptions, supposed to be very much alike. The significant effects for exercise can, therefore, be considered partial confirmation of the COFT's matrix structure.

Number of Rounds Fired

The analyses indicate no significant effect of the mask on the number of rounds fired, although the exercises themselves show significance in the number of rounds fired by exercise. In Exercise 1 the crews used fewer rounds than in the other two. Again, since Exercise 1 is less difficult than the others, fewer rounds might be expected to be fired. Little difference is found between Exercises 2 and 3.

The finding that unmasked exercises used more rounds than masked exercises (although not significantly more) is difficult to interpret. It is possible to argue that gunners in masks were more cautious initially within a timed engagement sequence, because of the limits to their vision, and therefore fired a lower total number of rounds while masked. However, it is equally easy to argue that gunners without masks should have been more efficient in round application, and have fired fewer rounds to achieve success. The structure of the experiment as conducted did not lend itself to assessment of the quality of the actual performance by each crew on each exercise; such assessment would be better able to judge the relative performances (masked and unmasked) and determine if comparable performance levels in terms of grading produced round count differences.

However, caution must be used in treating the number of rounds fired. Round count in the COFT is somewhat artificial, since the computer stops counting rounds when a target is killed even if the crew continues to fire. Therefore a crew's final shots may not be recorded. A skilled crew will conserve rounds as fewer will be wasted and they will not overkill; however, in a masked condition, reduced acuity may impact on the ability to make adjustments. A crew may become cautious and reduce the number of rounds fired, or, in an effort to insure that the target is killed, fire more rounds.

Interaction between Masking and Exercise

The lack of significant interaction for the main effects shows that the individual exercises themselves were not contributing in any unique manner to the effects produced by the masking. The mask effects stand alone, and presumably therefore, would occur regardless of which exercises from the COFT matrix were fired.

Conclusions

This experiment was based on data from 27 BFV crews firing a very limited number of exercises, but it is apparent with even so small a sample of gunnery performance that wearing the NBC protective mask does have an unfavorable impact on the BFV crew. In each of the four key areas, target identification time, time to fire the first round, time to achieve the first hit, and time to kill the target, elapsed time was longer (indicating slower and therefore less desireable performance) for masked crews than for the same crews firing different replications of the same exercises without masks. Each of the elements, target identification time, times to fire, hit and kill is important in target engagement, and to achieve combat success, all times must be as low as possible. If personnel are to train as they intend to fight, they must train for the eventuality of NBC warfare, and be prepared to be successful in that environment.

Additionally, if the COFT is to fulfill its role as a combat trainer, then Bradley crews must practice NBC gunnery within the COFT. In units, NBC gunnery training is mandatory; in the institutional environment, student crews should be familiarized with masked gunnery, and given opportunity to practice. Instructors, too, should practice firing masked, lest their gunnery skills deteriorate.

This experiment could not explore the issue of whether performance with the mask improves with repeated use of the mask although the literature indicates that practice with the mask should improve performance. Informal comments from the crews indicated that they began to "get used to" the mask after a

while. Their performance, however, did not reflect improvement, but a sample of three exercises is too limited to be of predictive value. The individual exercises within each condition (masked versus unmasked) were deliberately counterbalanced to preclude order effects; further experimentation might reveal optimum sequencing of training to increase the speed of adaptation to it.

A longer follow-on experiment, as well as one with inexperienced subjects, could generate data on the subject of repeated masking, and would help in an attempt to determine how much training would be required to overcome the negative effects. Experimentation with the addition of gloves should also be undertaken to determine if the lack of dexterity produces further decrement.

Similarly, other research could determine if the impact of the mask varies with gunnery skill level. This might help to answer the still unresolved question of whether the mask should be introduced early in gunnery training, or whether it should be left until basic gunnery skills have been mastered. There is no argument against the suggestion that the protective mask should be donned at some point during Bradley training. However, it may be dysfunctional during initial training, and might better be left until the student is sufficiently skilled to tolerate the distractor.

Finally, research should be conducted to determine the effects of different levels of MOPP, including full MOPP4, on gunnery performance in the Bradley, and in its primary gunnery simulator, the BFV COFT. Other research indicates that overall tactical performance by personnel in MOPP gear is poor. If performance under actual or simulated NBC conditions can be improved by the use of MOPP gear in the training simulators, such training should be initiated as soon as possible.

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APPENDIX A

DESCRIPTION OF EXERCISES
(From General Electric, 1984)

WARM UP EXERCISE: 53333

STATIONARY BFV - SHORT RANGE MULTIPLE MOVING TARGETS - GUNNER - PRECISION - ISU - NORMAL - DAY - NBC - FRIENDLY & ENEMY FIRE

GROUP	TARGET	RANGE	SPEED	VIEW	AMMO
1	APC	1330	14 MPH	FULL L	AP
	APC	1300	12 MPH	FULL L	AP
2	TANK	1340	9 MPH	FULL 45 R	TOW
	APC	1410	10 MPH	FULL FRONT	AP
3	APC	1360	9 MPH	FULL 45 R	AP
	M60A3	1370	10 MPH	45 R	N/A
4	APC	1320	12 MPH	FULL 45 R	AP
	CHOPPER	1460	18 MPH	FULL R	AP
5	TRUCK	1210	10 MPH	FULL 45 R	HE
	APC	1330	11 MPH	FULL R	AP

EXERCISE 1: 53313

STATIONARY BFV - SHORT RANGE MULTIPLE MOVING TARGETS - GUNNER - PRECISION - ISU - NORMAL - DAY - FRIENDLY & ENEMY FIRE

GROUP	TARGET	RANGE	SPEED	VIEW	AMMO
1	TANK	1280	15 MPH	FULL 45 L	TOW
	M2/M3	1300	11 MPH	FULL 45 L	-
2	TRUCK	1190	14 MPH	FULL R	HE
	APC	1300	17 MPH	FULL R	AP
3	APC	1320	14 MPH	FULL 45 L	AP
	TANK	1280	14 MPH	FULL 45 L	TOW
4	APC	1300	13 MPH	FULL 45 R	AP
	CHOPPER	1430	30 MPH	FULL R	AP
5	APC	1300	17 MPH	FULL R	AP
	APC	1200	15 MPH	FULL R	AP

EXERCISE 2: 54313

STATIONARY BFV - LONG RANGE MULTIPLE MOVING TARGETS - GUNNER - PRECISION - ISU - NORMAL - DAY - FRIENDLY & ENEMY FIRE

GROUP	TARGET	RANGE	SPEED	VIEW	AMMO
1	TRUCK	1820	14 MPH	FULL R	HE
	APC	1990	12 MPH	FULL R	AP
2	TANK	2000	13 MPH	FULL 45 L	TOW
	APC	2050	13 MPH	FULL FRONT	AP
3	APC	2010	13 MPH	FULL 45 R	AP
	M1	2050	15 MPH	FULL 45 R	N/A
4	TRUCK	1970	14 MPH	FULL R	HE
	CHOPPER	1960	28 MPH	FULL 45 R	AP
5	APC	1750	14 MPH	FULL L	AP
	APC	1950	12 MPH	FULL L	AP

EXERCISE 3: 54333

STATIONARY BFV - LONG RANGE MULTIPLE MOVING TARGETS - GUNNER - PRECISION - ISU - NORMAL - DAY - NBC - FRIENDLY & ENEMY FIRE

GROUP	TARGET	RANGE	SPEED	VIEW	AMMO
1	TRUCK	1690	13 MPH	FULL L	HE
	APC	1890	15 MPH	FULL 45 L	AP
2	APC	1880	14 MPH	FULL 45R	AP
	TANK	2010	20 MPH	FULL 45R	TOW
3	APC	1720	13 MPH	FULL R	AP
	APC	1940	20 MPH	FULL 45 R	AP
4	TANK	1970	15 MPH	FULL 45 L	TOW
	CHOPPER	2040	30 MPH	FULL 45 L	AP
5	TRUCK	1680	13 MPH	FULL R	HE
	APC	2020	15 MPH	FULL 45 R	AP

APPENDIX B

STATISTICAL INFORMATION

Table B-1

Identification Times (Seconds) with and without the Mask

CREW	EX 1 WO	EX 1 W	EX 2 WO	EX 2 W	EX 3 WO	EX 3 W
01	7.4	5.7	4.1	9.3	3.4	6.9
02	0.6	1.2	1.2	4.1	1.6	1.3
03	3.8	6.1	5.7	13.7	4.1	9.7
04	8.5	8.9	7.1	9.6	6.7	9.1
05	3.3	4.8	3.7	6.2	3.8	3.8
06	*	7.1	8.0	8.4	7.5	5.9
07	5.5	6.5	13.7	10.2	5.9	6.2
08	4.3	5.8	*	6.4	7.1	4.8
09	2.1	1.4	3.1	5.1	1.9	2.3
10	2.6	3.4	7.2	5.6	6.7	4.7
11	3.1	6.5	7.8	6.6	7.2	7.4
12	6.2	5.3	9.5	8.5	10.2	10.8
13	8.3	9.6	7.0	11.1	5.6	4.1
14	2.5	4.8	5.1	6.4	3.1	7.4
15	3.6	2.4	7.1	4.2	1.7	3.6
16	2.8	2.4	4.0	7.2	2.6	4.3
17	3.0	3.4	11.8	4.9	5.1	6.2
18	3.1	5.4	6.6	10.7	2.8	5.8
19	1.5	1.8	6.7	3.4	4.9	4.5
20	4.5	7.4	3.8	5.9	4.7	5.2
21	5.0	5.2	5.0	8.3	6.7	4.5
22	2.9	4.1	5.8	7.2	5.4	3.5
23	2.7	10.8	10.2	16.3	4.2	12.0
24	1.6	4.8	2.7	9.0	1.9	4.6
25	4.8	3.5	7.1	5.3	6.7	8.0
26	3.4	4.8	7.7	5.0	5.6	10.4
27	3.7	2.5	4.9	7.9	4.2	5.0
28	2.6	4.0	5.1	5.0	4.6	6.6
29	3.4	4.4	4.7	7.0	6.0	6.6
M	3.80	4.86	6.24	7.54	4.71	6.09
SD	1.96	2.39	2.77	3.02	2.02	2.63

Note. Missing data are indicated by an *. Scores for these crews are not included in statistics.

Table B-2

Times to Fire (Seconds) with and without the Mask

CREW	EX 1 WO	EX 1 W	EX 2 WO	EX 2 W	EX 3 WO	EX 3 W
01	16.4	16.7	14.7	23.5	12.0	22.8
02	18.3	13.1	19.9	22.1	21.7	21.1
03	15.2	19.4	19.5	31.9	15.7	27.8
04	22.8	20.1	25.8	23.3	20.6	22.3
05	14.7	19.2	20.0	19.3	21.9	22.8
06	*	19.7	23.1	24.0	22.2	25.0
07	18.4	18.0	28.9	28.5	21.8	22.1
08	17.9	23.4	*	21.3	19.8	22.7
09	12.4	12.2	20.7	17.9	17.7	17.4
10	18.3	17.5	24.2	23.4	25.5	26.2
11	15.3	18.5	24.4	26.5	24.5	22.8
12	18.8	25.8	24.4	22.5	27.8	26.8
13	21.1	19.8	25.1	25.1	23.7	23.6
14	20.1	18.4	22.7	28.0	25.8	27.4
15	17.8	16.7	25.4	24.8	20.6	19.8
16	16.6	19.3	21.4	23.8	21.8	24.8
17	20.8	20.0	28.2	28.1	32.1	30.3
18	17.4	22.3	25.0	23.9	21.7	28.0
19	14.7	15.3	20.7	19.1	19.9	24.6
20	15.6	19.2	18.9	17.9	18.4	20.5
21	18.9	20.3	22.2	25.3	23.5	26.5
22	17.3	17.1	24.3	27.6	24.4	22.2
23	14.7	22.3	23.5	25.5	22.3	31.4
24	12.2	18.7	16.7	25.2	17.3	20.6
25	18.4	19.0	23.5	24.3	27.9	24.2
26	12.7	15.3	22.8	19.9	20.6	25.9
27	14.1	13.2	18.2	20.3	18.4	18.7
28	13.1	16.1	19.7	18.7	17.2	19.9
29	14.3	13.5	17.2	17.2	19.6	18.3
M	16.68	18.04	22.15	23.49	21.64	23.66
SD	2.81	3.08	3.45	3.77	4.19	3.63

Note. Missing data are indicated by an *. Scores for these crews are not included in statistics.

Table B-3

Times to Hit the Target (Seconds) with and without the Mask

CREW	EX 1 WO	EX 1 W	EX 2 WO	EX 2 W	EX 3 WO	EX 3 W
01	15.4	19.5	19.6	25.4	17.2	22.9
02	24.6	16.1	26.6	25.7	27.7	24.6
03	18.6	22.9	23.0	38.4	21.1	33.0
04	26.7	25.5	28.0	30.0	27.5	28.8
05	20.4	22.1	20.8	24.0	23.8	27.2
06	*	23.5	24.7	27.1	27.5	31.0
07	23.1	23.0	34.1	28.8	25.8	25.4
08	22.6	27.6	*	30.8	23.5	28.7
09	15.2	14.7	25.6	22.1	21.3	22.7
10	23.1	21.0	27.2	29.4	31.4	28.5
11	19.3	20.8	30.2	31.9	26.8	25.4
12	21.5	28.3	29.4	27.8	29.6	29.3
13	24.0	22.4	27.8	30.9	28.0	29.8
14	21.1	23.1	25.9	32.9	27.9	24.0
15	21.1	19.7	29.9	28.1	25.0	23.2
16	20.3	22.1	28.1	23.8	24.2	25.0
17	23.8	25.9	32.9	31.7	34.5	31.6
18	20.8	24.2	25.0	26.3	25.9	31.7
19	17.1	17.5	23.9	24.1	22.4	28.1
20	17.8	22.1	22.6	23.5	22.2	25.1
21	22.7	22.4	25.6	29.1	27.3	30.2
22	20.4	20.2	26.0	29.1	27.3	25.7
23	19.7	26.3	29.5	28.4	26.9	32.6
24	14.7	21.4	20.2	28.2	22.3	24.1
25	20.7	21.0	26.5	31.7	27.1	26.9
26	15.4	18.0	26.6	24.3	24.5	29.7
27	18.0	16.2	22.4	25.6	22.1	24.0
28	15.9	19.3	24.7	23.4	22.2	24.3
29	17.3	17.7	20.3	21.6	24.3	22.3
M	19.95	21.24	26.01	27.64	25.42	26.89
SD	3.20	3.28	3.72	3.87	3.58	3.24

Note. Missing data are indicated by an *. Scores for these crews are not included in statistics.

Table B-4

Times to Kill the Target (Seconds) with and without the Mask

CREW	EX 1 WO	EX 1 W	EX 2 WO	EX 2 W	EX 3 WO	EX 3 W
01	22.7	21.0	19.8	28.8	23.0	27.1
02	27.6	17.6	25.4	29.4	29.0	27.4
03	22.2	24.3	26.0	37.3	25.0	34.7
04	29.6	28.3	32.2	33.7	30.9	33.2
05	22.6	23.6	24.6	25.1	26.7	29.2
06	*	25.9	24.3	28.2	32.7	33.3
07	26.2	25.5	34.5	35.2	34.1	31.0
08	24.7	31.1	*	35.1	28.4	32.7
09	17.3	17.0	29.1	24.7	25.5	25.2
10	26.4	24.3	30.2	31.0	29.8	29.3
11	20.9	23.6	33.3	33.9	30.3	25.7
12	23.5	29.0	33.6	31.1	34.3	32.4
13	26.3	24.6	30.9	32.1	32.5	30.0
14	25.1	27.2	29.8	28.2	30.4	27.4
15	22.7	20.5	31.4	33.9	30.9	26.6
16	22.3	26.2	25.9	27.3	24.4	25.2
17	26.1	26.8	33.6	33.8	38.2	35.2
18	23.7	26.8	27.8	33.5	29.3	35.3
19	19.5	20.4	25.8	26.8	26.0	31.6
20	19.6	24.1	25.5	31.8	26.0	27.5
21	24.8	24.6	28.8	29.9	29.6	33.0
22	24.7	22.6	29.1	30.4	30.1	30.3
23	23.3	28.5	33.7	28.9	30.6	37.1
24	16.6	22.7	22.9	31.0	25.0	27.7
25	23.1	23.7	31.1	33.1	31.6	30.0
26	17.8	19.8	28.8	28.3	27.7	34.3
27	20.5	18.5	27.6	28.5	25.4	26.4
28	17.2	20.8	28.1	26.3	24.6	27.4
29	19.1	20.1	24.9	26.1	25.1	25.5
M	22.64	23.41	28.68	30.37	28.74	29.84
SD	3.40	3.34	3.68	3.27	3.65	3.54

Note. Missing data are indicated by an *. Scores for these crews are not included in statistics.

Table B-5

Number of Rounds Fired with and without the Mask

CREW	EX 1 WO	EX 1 W	EX 2 WO	EX 2 W	EX 3 WO	EX 3 W
01	102	47	83	72	126	70
02	45	31	37	46	89	63
03	95	67	77	116	165	91
04	55	59	72	81	93	112
05	48	49	64	83	77	51
06	*	64	71	86	94	117
07	77	68	124	93	108	84
08	61	64	*	63	79	91
09	50	51	76	57	78	61
10	80	76	76	101	108	79
11	51	63	88	90	68	66
12	49	48	118	88	88	88
13	64	42	76	107	80	63
14	67	105	119	97	74	64
15	60	74	90	87	100	78
16	61	90	141	106	114	113
17	57	86	74	74	45	81
18	82	63	110	110	80	98
19	54	42	77	73	65	116
20	49	65	69	82	79	68
21	62	56	63	69	66	77
22	64	50	56	53	73	61
23	68	87	109	106	120	88
24	65	40	101	113	108	102
25	44	43	61	51	57	49
26	54	48	83	81	74	89
27	61	56	73	63	65	58
28	45	54	78	71	74	70
29	58	58	106	75	83	62
M	61.74	59.93	85.41	83.15	87.30	77.85
SD	14.73	17.48	23.70	19.75	25.15	18.77

Note. Missing data are indicated by an *. Scores for these crews are not included in statistics.

Table B-6

Analysis of Variance for ID Time

SOURCE	DF	TYPE III SS	MS	F	P
EXERCISE	2	179.12	89.56	25.52	0.0001
Error (EXERCISE)	52	182.50	3.51		
MASK	1	63.09	63.09	10.40	0.0034
Error (MASK)	26	157.67	6.06		
EXERCISE*MASK	2	0.76	0.38	0.16	0.8566
Error (EXERCISE*MASK)	52	126.63	2.44		

Table B-7

Analysis of Variance for FIRE Time

SOURCE	DF	TYPE III SS	MS	F	P
EXERCISE	2	1040.80	520.40	85.39	0.0001
Error (EXERCISE)	52	316.90	6.09		
MASK	1	99.72	99.72	8.81	0.0063
Error (MASK)	26	294.13	11.31		
EXERCISE*MASK	2	4.02	2.01	0.48	0.6188
Error (EXERCISE*MASK)	52	215.98	4.15		

Table B-8

Analysis of Variance for HIT Time

SOURCE	DF	TYPE III SS	MS	F	P
EXERCISE	2	1263.72	631.86	125.40	0.0001
Error (EXERCISE)	52	262.01	5.04		
MASK	1	86.39	86.39	7.34	0.0118
Error (MASK)	26	306.09	11.77		
EXERCISE*MASK	2	0.77	0.39	0.08	0.9216
Error (EXERCISE*MASK)	52	244.88	4.71		

Table B-9

Analysis of Variance for KILL Time

SOURCE	DF	TYPE III SS	MS	F	P
EXERCISE	2	1467.56	733.78	130.83	0.0001
Error (EXERCISE)	52	291.65	5.61		
MASK	1	57.01	57.01	6.41	0.0178
Error (MASK)	26	231.39	8.90		
EXERCISE*MASK	2	5.94	2.97	0.57	0.5700
Error (EXERCISE*MASK)	52	271.68	5.22		

Table B-10

Analysis of Variance for ROUNDS Fired

SOURCE	DF	TYPE III SS	MS	F	P
EXERCISE	2	18453.68	9226.84	34.44	0.0001
Error (EXERCISE)	52	13930.65	267.90		
MASK	1	822.37	822.37	3.82	0.0616
Error (MASK)	26	5601.79	215.45		
EXERCISE*MASK	2	495.16	247.58	1.03	0.3651
Error (EXERCISE*MASK)	52	12531.17	240.98		